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LINEAR VIBRATION MOTOR
[Rinia shindo mota]

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[Claims] /2*

[Claim 1] A linear vibration motor provided with movable magnet bodies capable of being displaced in a shaft direction and disposed in magnetic gaps of a stator core having coils, wherein:

the movable magnet bodies include permanent magnets divided into many parts and insulating means provided between the permanent magnets.

[Claim 2] The linear vibration motor according to Claim 1, wherein the stator core includes a first magnetic body core having the coil and a second magnetic body core opposing the first magnetic body core with the magnetic gaps interposed therebetween, and the second magnetic body core is able to move in tandem with the movable magnet bodies.

[Claim 3] The linear vibration motor according to Claim 1 or 2, wherein the insulating means includes an insulating thin film or an insulating coating.

[Claim 4] The linear vibration motor according to Claim 1 or 2, wherein the insulating means includes an insulating membrane covering each of the permanent magnets.

[Claim 5] The linear vibration motor according to any one of Claims 1-4, wherein the permanent magnets are arranged such that polarities of adjacent magnets are mutually opposite.

* Claim and paragraph numbers correspond to those in the foreign text.

[Claim 6] The linear vibration motor according to any one of Claims 1-5, wherein the permanent magnets and the insulating means are held by a frame body.

[Claim 7] The linear vibration motor according to Claim 6, wherein the frame body is formed by an insulating material or is treated so as to be insulating.

[Claim 8] A linear vibration motor provided with movable cores capable of being displaced in a shaft direction and disposed in magnetic gaps into which permanent magnets of a stator core having coils are mounted, wherein:

the permanent magnets are divided into multiple parts and include insulating means provided between the magnets.

[Claim 9] The linear vibration motor according to Claim 8, wherein the insulating means includes an insulating thin film or an insulating coating.

[Claim 10] The linear vibration motor according to Claim 8, wherein the insulating means includes an insulating membrane that covers each of the divided magnets.

[Detailed Description of the Invention]

[0001]

[Industrial Field of Use] The present invention relates to a linear vibration motor, and more particularly relates to a linear vibration motor provided with movable bodies that are displaced in a

shaft direction and are disposed to magnetic gaps formed in, for example, a stator core.

[0002]

[Prior Art] Conventional linear vibration motors are as shown by the schematic configuration in Fig. 7, for example. This linear vibration motor 1 is constituted by a first magnetic body core 2 that has a cross-section shape substantially in the form of the letter "E," a coil 3 mounted on a center yoke 2a of the first magnetic body core 2, movable magnets 4 disposed to an open end of the first magnetic body core 2 and a tabular second magnetic body core 5 sandwiched between these movable magnets 4 and disposed opposite the first magnetic body core 2. The movable magnets 4 are constituted by adhering to the two permanent magnets 4a and 4b which are magnetically attached in the direction shown by the arrow in the drawing, and the second magnetic body core 5, together with the first magnetic body core 2, constitutes a stator core 6.

[0003] In the linear vibration motor 1 thus constituted, magnetic flux is generated by passing a current through the coil 3, and this magnetic flux flows along a magnetic path constituted by the first magnetic body core 2 and the second magnetic body core 5. By changing the direction of the current flowing through the coil 3, or in other words by passing an AC current to the coil 3, the direction of the magnetic flux flowing along the magnetic path is changed. By changing the direction of the magnetic flux flowing through the

magnetic path using an AC current in this manner causes the movable magnets 4 to move left and right continuously. As a result, the movable magnets 4 move in a reciprocating motion, and this reciprocating force drives a reciprocating-type compressor, by being transmitted to a piston, for example.

[0004]

[Problem to Be Solved by the Invention] In a linear vibration motor thus constituted, an eddy current is created in a direction perpendicular to the page in the drawings. This eddy current causes damage to the first magnetic body core, the movable magnets, and the second magnetic body core, thus lowering the efficiency of the motor.

[0005] Incidentally, strategies have been implemented for blocking the eddy current in the first magnetic body core and the second character [sic] magnetic body core, but the current situation is that no particular strategies have been implemented for the movable magnets 4.

[0006] Namely, since the movable magnets 4 are constituted by putting in contact the two permanent magnets 4a and 4b which have different polarities, and eddy current is generated straddling adjacent magnets. There exists the problem that damage due to this eddy current lowers the efficiency of the motor and also reduces the reliability due to demagnetization because of heat produced in the magnets.

[0007] Therefore, a main object of the present invention is to provide a linear vibration motor that reduces damage from eddy currents created in the magnets and has high reliability with low demagnetization, and high efficiency.

[0008]

[Means for Solving the Problem] The present invention is a linear vibration motor provided with movable magnet bodies capable of being displaced in a shaft direction and disposed in magnetic gaps of a stator core having coils, wherein the movable magnet bodies include permanent magnets divided into many parts and insulating means provided between the permanent magnets.

[0009] Furthermore, the present invention is a linear vibration motor provided with movable cores capable of being displaced in a shaft direction and disposed in magnetic gaps into which permanent magnets of a stator core having coils are mounted, wherein the permanent magnets are divided into multiple parts and include insulating means provided between the magnets.

[0010]

[Operation] Movable magnet bodies disposed in the magnetic gaps formed in the stator core are insulated by an insulating means provided between the permanent magnets divided into many parts, and therefore the eddy current is blocked by this insulating means. Even in a case in which the movable core bodies are disposed in magnetic gaps in which permanent magnets of a stator core are mounted, the

permanent magnets can be divided and eddy currents among the permanent magnets can be blocked by the insulating means provided among the magnets.

[0011]

[Effects of the Invention] With the present invention, core loss due to eddy currents created by permanent magnets can be reduced in a linear vibration motor, thus improving the efficiency of a motor. Generation of heat in the magnets can also be reduced, thus raising the reliability by making demagnetization more difficult.

[0012] The object described above, as well as other objects, features, and advantages of the present invention shall become clearer from the detailed description of embodiments below, with reference to the drawings.

[0013]

[Embodiments] Embodiments of the present invention are described below with reference to Figs. 1-6.

[0014] A moving magnet (MM)-type linear vibration motor 10, which is one embodiment of the present invention and is shown in Fig. 1, includes a first magnetic body core 12 having a cross-section substantially in the shape of the letter "E," a stator core 18 constituted by a coil 14 mounted to a center yoke 12a in the first magnetic body core 12 and a second magnetic body core 16 having a cross-section substantially in the shape of the letter "I" disposed opposite and separated from an open end of the first magnetic body

core 12, and a moving magnet body 22 capable of displacement in a shaft direction and disposed in a magnetic gap 20 formed by the first magnetic body core 12 and the second magnetic body core 16.

[0015] The moving magnetic body 22 includes permanent magnets 24, 24 and 26, 26 divided into four pieces, and a thin film insulating material 28,... is provided between each of the permanent magnets 24 and 24, 24 and 26, and 26 and 26, thus providing a thin insulation between the magnets. The permanent magnets 24, 24 and the permanent magnets 26, 26 are arranged such that the permanent magnets 24, 24 are magnetized in the same direction, and the permanent magnets 26, 26 are magnetized in a direction opposite that of the permanent magnets 24, 24. Note that if the permanent magnets are insulated from one another by the thin film insulating material 28, then it is also possible to constitute the moving magnet body 22 by covering the permanent magnets 24 and 26, for example, with an insulating coating ahead of time. Furthermore, the same effect can be achieved by forming a coating film (for example, using epoxy spray coating or the like) by coating an insulating material 28 on adjacent faces of the magnets or over the entirety of the magnets.

[0016] With the above constitution, passing a current in the direction shown in the drawings through the coil 14 causes a magnetic flux to flow in the direction of the dotted arrow in the drawings in the stator core 18 constituted by the first magnetic body core 12 and the second magnetic body core 16, and causes the magnetic pole of the

first magnetic body core 12 to be S-N-S as shown in the drawings. On the other hand, since the four permanent magnets 24 and 26 that constitute the moving magnet body 22 are magnetized as shown in the drawings, this moving magnet body 22 is moved to the right by a propulsive force in the direction shown by the arrow due to repulsion and attraction. Furthermore, if the direction of the current flowing in the coil 14 is reversed, the flow of the magnetic flux takes the direction shown by the dotted arrow in the drawings, and the magnetic polarity of the first magnetic body core 12 is reversed, becoming N-S-N. As a result, the repulsion and attraction acting on the moving magnet body 22 are reversed, and the moving magnet body 22 is moved to the left by a propulsive force in a direction opposite the direction of the solid arrow in the drawings.

[0017] Accordingly, the moving magnet body 22 is moved in a continuous reciprocal motion by applying an AC current to the coil 14. A linear vibration motor can be provided in which core loss due to eddy currents in the moving magnet body 22 are decreased because the eddy current is blocked by the permanent magnets 24, 26 divided into many pieces and the insulating material 28 provided between the magnets, and efficiency and reliability are improved as no demagnetization occurs because heat production is limited.

[0018] Another variation shown in Fig. 2 only differs in the constitution of the moving magnet body 22 when compared to the embodiment of Fig. 1. Other portions are the same, and therefore the

same reference numerals are used for those portions, and description thereof has been omitted. Specifically, the moving magnetic body 22 includes permanent magnets 24, 24 and 26, 26 divided into four pieces, and a thin film insulating material 28,... is provided between each of the permanent magnets 24 and 24, 24 and 26, and 26 and 26, and the permanent magnets 24, 26 and the insulating material 28 are held as a single unit by an insulation holding frame 30. The insulation holding frame 30 may be formed using, for example, a synthetic resin material, or by forming an insulation coating on a surface of a metal frame. Note that operation in this case is the same as in the case of the embodiment shown in Fig. 1, and therefore description thereof is omitted.

[0019] Next is described a moving iron (MI)-linear vibration motor 10 which is another embodiment of the present invention, with reference to Fig. 3. Note that portions of the constitution corresponding to the embodiment of Fig. 1 are given the same reference numerals in the description below.

[0020] This linear vibration motor 10 includes a stator core 18 having a cross-section substantially in the shape of the letter "C," a coil 14 disposed in a slot of the stator core 18, a moving core body 32 which displaces in a shaft direction and is disposed in a magnetic gap 20 of the open-end side of the stator core 18, and permanent magnets 24, 26 which are mounted opposing faces of the stator core 18 which form the magnetic gap 20. The permanent magnets

24 and 26 are divided into magnets 24a and 24b and magnets 26a and 26b, respectively, and are insulated from one another by providing a thin film insulating material 28, 28 between the divided magnets. The pairs of magnets 24a and 24b and magnets 26a and 26b are arranged such that they are magnetized in opposite directions. As another variation, the same effect can be provided by covering each of the divided magnets with an insulation coating that is not shown in the drawings. Note that the moving core body 32 is formed by stacking in the shaft direction magnetic steel plates having a predetermined shape.

[0021] Operation of this embodiment is now described. By changing the direction of the current flowing in the coil 14, the direction of the magnetic flux flowing through the magnetic path formed by the stator core 18 is changed, and the moving core body 32 is caused to move left and right. Specifically, when a current is passed through the coil 14, the magnetic poles of the open-end portion of the stator core 18 become N-S as shown in drawing, and the pair of magnets 24a and 24b and the other pair of magnets 26a and 26b opposing the magnetic gap 20 in which the moving core body 32 is disposed are magnetized in the directions shown by the arrows, and therefore the magnetic flux of the magnets 24a and 26a to the right is intensified by the magnetic flux flowing through the stator core 18, and the magnetic flux of the magnets 24b and 26b to the left side is weakened. As a result, the magnetic core 32 moves to the right due

to the propulsive force in the direction in which the magnetic flux is intensified, namely the direction of the solid arrow in the drawing.

[0022] Changing the direction of the current flowing through the coil 14 causes the magnetic poles of the open-end portion of the stator core 18 to reverse, and therefore the direction of the magnetic flux flowing through the stator core 18 to change to S-N. As a result, the magnetic flux of the magnets 24a and 26a to the right is weakened, and the magnetic flux of the magnets 24b and 26b to the left is intensified, causing the moving core body 32 to move to the left, or in other words the direction of the intensified magnetic flux.

[0023] Accordingly, by supplying an AC current to the coil 14, the moving core body 32 is caused to move in a continuous reciprocal motion, and if a piston or the like were linked to this moving core body 32, a compressor for air or refrigerant could be driven. In this embodiment, too, eddy currents are blocked because the permanent magnets 24 and 26 are divided and the divided magnets are insulated from one another by an insulating material.

[0024] Furthermore, Fig. 4 is a variation of the MI-type linear vibration motor 10 indicating another embodiment according to the present invention. This linear vibration motor 10 is constituted by a first magnetic body core 12 having a cross-section substantially in the shape of the letter "U," whereby a coil 14 is provided to a slot

and permanent magnets 24 and 26 are mounted to open-end portions, a second magnetic body core 16 having a cross-section substantially in the shape of the letter "I," in which the permanent magnets 24 and 26 are disposed opposite the open-end of the first magnetic body core 12 and mounted positions mutually opposing the permanent magnets 24 and 26, and a moving core body 32 which displaces in the shaft direction and is disposed in a magnetic gap 20 of the stator core 18 formed by the first magnetic body core 12 and the second magnetic body core 16.

[0025] The permanent magnets 24 and 26 are each divided into a pair of magnets 24a and 24b and magnets 26a and 26b, and an insulating material 28 is provided between the pair of magnets 24a and 24b and the pair of magnets 26a and 26b, thus electrically insulating the magnets from each other.

[0026] Furthermore, the pair of magnets 24a and 24b and the pair of magnets 26a and 26b are arranged so as to be magnetized in the directions shown by the arrows in the drawing. The moving core body 32 is provided with two laminated cores 36 linked with spaces therebetween by a shaft 34. The laminated cores 36 are affixed to the shaft 34 so as to be positioned in gaps surrounded by the permanent magnets 24 and 24 and the permanent magnets 26 and 26 which are disposed opposite one another.

[0027] A detailed description of operation of the MI-type linear vibration motor 10 of the present variation is omitted as it is the same as the previous embodiment shown in Fig. 3. In the state shown

in the drawing, when a current is applied to the coil 14, the magnetic poles of the open-end side portion of the first magnetic body core 12 become N-S, and, depending on the direction of the current, the magnetic flux generated by the current intensifies the magnets 24b and 26a of the magnets 24a and 24b and the magnets 26a and 26b adjacent to the permanent magnets 24 and 26, and weakens the other magnets 24a and 26b, therefore causing a propulsive force to move the two laminated cores 36 towards the side in which the magnetic flux has been strengthened, and causing the moving core body 32 to move to the right. If the direction of the current flowing through the coil 14 is reversed, the magnetic poles of the open-end portion of the first magnetic body core 12 is reversed, becoming S-N, and the direction of the magnetic flux flowing through the magnetic path is also reversed, causing the moving core body 32 to move to the left. Accordingly, if an AC current is applied to the coil 14, the moving core body 32 moves in the continuous reciprocating motion, and if a piston were linked to the shaft 34 of the moving core body 32, a reciprocating-type compressor could be driven.

[0028] Furthermore, Fig. 5 shows another embodiment of the MI-type linear vibration motor 10. In this motor 10, the stator core 18 is formed as a cylinder, with four yokes 18a, 18b, 18c, and 18d provided to an interior side thereof, the yolks being wound by a coil 14, and permanent magnets 24 having a cross-section in the shape of a circular arc being affixed by an adhesive agent to the ends of the

yokes as stator magnets. A rod-like moving core body 32 with a shaft portion penetrating the center thereof is disposed so as to be freely displaceable in the shaft direction to an internal space 20 of the stator core 18. The permanent magnets 24 are, like previous embodiments, divided into two parts, namely magnets 24a and 24b, the magnets being electrically insulated from one another by providing an insulating material 28 between the magnets. In this case, too, the magnets may be insulated from one another by coating the magnets 24a and 24b using an insulating coating instead of the insulating material 28.

[0029] Note that operation of this embodiment is the same as that of other embodiments described above, and therefore in essence supplying an AC current to the core 14 causes the direction and intensity of the magnetic flux to change, and the moving core body 32 to move left and right in a reciprocating motion as shown in Fig. 5 (b).

[0030] Furthermore, Fig. 6 shows a variation of the MM-type linear vibration motor 10, and, when compared with the embodiment shown in Fig. 1, a second magnetic body core 16 having an "I"-shaped cross-section and constituting the stator core 18 is a moving part formed integrally by being affixed to the moving magnet body 22, and moves left and right in a reciprocating motion with respect to the first magnetic body core 12 having an "E"-shaped cross-section and around which the coil 14 is wound, with a magnetic space 20

interposed therebetween. Other portions of the constitution are substantially the same as the embodiment of Fig. 1, and therefore the same reference numerals are assigned and description thereof is omitted. The operating principle is also the same, and therefore description thereof is also omitted.

[Brief Description of the Drawings]

[Fig. 1] is a schematic view showing an MM-type linear vibration motor which is one embodiment of the present invention.

[Fig. 2] is a view showing a schematic constitution of a variation of Fig. 1.

[Fig. 3] is a schematic view showing an MI-type linear vibration motor which is another embodiment.

[Fig. 4] is a view of a different embodiment corresponding to Fig. 3.

[Fig. 5] (a) and (b) are a plane view and a cross-section view of major components of an MI-type linear vibration motor which is yet another embodiment.

[Fig. 6] is a view of a variation of the MM-type linear vibration motor show in Fig. 1.

[Fig. 7] is a view of a conventional embodiment corresponding to Fig. 1.

[Explanation of the Reference Numerals]

10 linear vibration motor

12 first magnetic body core

14 coil

16 second magnetic body core

18 stator core

20 magnetic

22 moving magnet bodies

24, 26 permanent magnets

28 insulating material

30 insulated holding frame

32 moving core body

36 laminated core

Figure 1

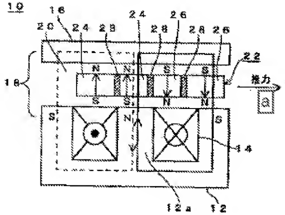
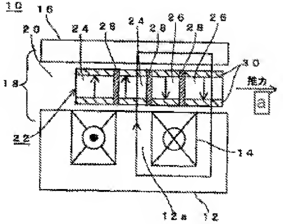


Figure 2



Key: a) Thrust

Figure 3

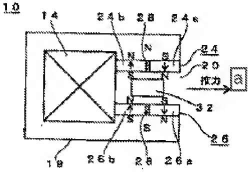
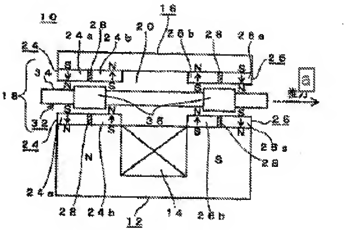


Figure 4



Key: a) Thrust

Figure 6

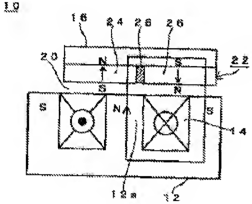


Figure 5

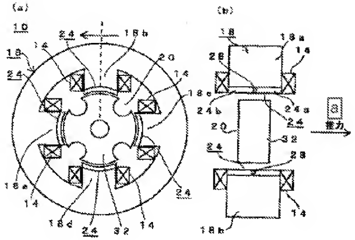
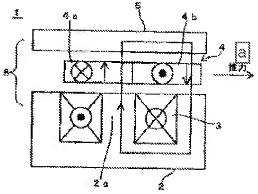


Figure 7



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